ERDC/EL TR-02-3

Environmental Laboratory

US Army Corps of Engineers®
Engineer Research and Development Center

20020502 120

Wetlands Research Program

Hydrogeomorphic Approach to Assessing Wetland Functions: Guidelines for Developing Regional Guidebooks

Chapter 1
Introduction and Overview of the Hydrogeomorphic Approach

Ellis J. Clairain, Jr.

March 2002

PRINTED ON RECYCLED PAPER

Wetlands Research Program

ERDC/EL TR-02-3
March 2002

Hydrogeomorphic Approach to Assessing Wetland Functions: Guidelines for Developing Regional Guidebooks

Chapter 1
Introduction and Overview of the Hydrogeomorphic Approach

by Ellis J. Clairain, Jr.

Environmental Laboratory
U.S. Army Engineer Research and Development Center
3909 Halls Ferry Road
Vicksburg, MS 39180-6199

Final report

Prepared for U.S. Army Corps of Engineers
Washington, DC 20314-1000

Under CRWRP Work Unit 32985

Corps of Engineers Research Report Summary, March 2002

Assessing Wetland Functions

Hydrogeomorphic Approach to Assessing Wetland Functions: Guidelines for Developing Regional Guidebooks: Chapter 1. Introduction and Overview of the Hydrogeomorphic Approach (ERDC/EL TR-02-3)

ISSUE: Section 404 of the Clean Water Act directs the U.S. Army Corps of Engineers to administer a regulatory program for permitting the discharge of dredged or fill materials in "waters of the United States." As part of the permit review process, the impacts of discharging dredged or fill material on wetland functions must be assessed. On 16 August 1996, a National Action Plan to Implement the Hydrogeomorphic Approach for developing Regional Guidebooks to assess wetland functions was published. A series of Regional Guidebooks will be published in accordance with the National Action Plan.

To facilitate development of Regional Guidebooks and ensure consistency and quality control, a set of guidelines were prepared. These guidelines are provided in the report, "Hydrogeomorphic Approach to Assessing Wetland Functions: Guidelines for Developing Regional Guidebooks." It provides detailed information for anyone wishing to develop Regional Guidebooks and consists of nine chapters. Each chapter is briefly described below.

Chapter 1, "Introduction and Overview of the Hydrogeomorphic Approach." This report introduces the Hydrogeomorphic Approach and outlines steps necessary to prepare Regional Guidebooks. It also provides the format for each Regional Guidebook and consistent terminology.

Chapter 2, "Identifying and Characterizing Regional Subclasses." This chapter provides further guidance on classifying wetlands into classes using geomorphic setting, water source, and hydrodynamics and further subdivides classes into subclasses using other region-specific characteristics.

Chapter 3, "Identifying Reference Wetlands." This chapter defines key terms related to reference wetlands. It also describes their purpose and gives guidance on how to select reference wetlands.

Chapter 4, "Developing Assessment Models." This chapter provides guidance for selecting and defining wetland functions, developing the initial conceptual models and variables for each function and refining the conceptual models. Guidance is also provided for developing variable subindexes and for aggregating variables into final models.

Chapter 5, "Collecting and Managing Reference Data." This chapter includes guidance for maintaining quality control when collecting reference data, determining minimum sample requirements, selecting different types of field measures, and entering and analyzing data.

Chapter 6, "Calibrating Assessment Models Using Reference Wetland Data." This chapter includes different options for calibrating reference

About the Author: Dr. Ellis J. Clairain, Jr., is a research aquatic biologist at the U.S. Army Engineer Research and Development Center, Environmental Laboratory, Vicksburg, MS. **Point of Contact:** Dr. Russell Theriot, CRWRP Program Manager, telephone (601) 634-2733 or e-mail *Russell.F.Theriot@ erdc.usace.army.mil*

data and converting reference data to subindices for each model variable.

Chapter 7, "Verifying, Field Testing, and Validating Assessment Models." This chapter defines each of the three title components and discusses steps necessary to conduct each activity. It also provides guidance for conducting a sensitivity analysis to test the influence of each variable on model outputs.

Chapter 8, "Developing the Assessment Protocol." The Assessment Protocol is one chapter of every regional guidebook. It provides the specific information necessary to collect data including red flag features, office and field equipment needs, plot layout, data collection procedures, and field sheets. Data collected are used to compute model outputs. This chapter includes guidance for preparing a list of red flag features, alternatives, and examples for collecting data for each model variable, and developing field sheets.

Chapter 9, "Application of the Hydrogeomorphic Approach." This chapter provides examples of how the results of an HGM analysis can be used to compare multiple wetlands of the same subclass, compute present and future potential project impacts, and determine mitigation requirements.

RESEARCH OBJECTIVE: The objective of this research was to develop a consistent framework for developing Regional Guidebooks. This report represents one of nine chapters in "Hydrogeomorphic Approach to Assessing Wetland Functions: Guidelines for Developing Regional Guidebooks." Each chapter is published separately.

SUMMARY: The Hydrogeomorphic (HGM) Approach is a collection of concepts and methods for developing functional indices, and subsequently using them to assess the capacity of a wetland to perform functions relative to similar wetlands in a region. The Approach was initially designed to be used in the context of the Clean Water Act Section 404 Regulatory Program permit review sequence to consider alternatives, minimize impacts, assess unavoidable project impacts, and monitor the success of mitigation projects. However, a variety of other potential applications for the Approach have been identified, including determining minimal effects under the Food Security Act, designing mitigation projects, and managing wetlands. This report is one of nine chapters of a larger report designed to provide consistent guidelines for developing regional guidebooks for implementing the HGM Approach.

AVAILABILITY OF REPORT: The report is available at the following Web site: *http://www.wes.army.mil/el/wetlands wlpubs.html.* The report is also available on Interlibrary Loan Service from the U.S. Army Engineer Research and Development Center (ERDC) Research Library, telephone (601) 634-2355, or the following Web site: *http://libweb.wes.army.mikl/index.htm.*

Contents

Preface

This chapter in the Guidelines for Developing Regional Guidebooks was authorized by Headquarters, U.S. Army Corps of Engineers (HQUSACE) as part of the Characterization and Restoration of Wetlands Research Program (CRWRP) Work Unit 32985, "Technical Development of HGM." Dr. Ellis J. Clairain, Jr., Environmental Laboratory (EL), U.S. Army Engineer Research and Development Center (ERDC), was the Principal Investigator for the work unit. Mr. Dave Mathis was the CRWRP Coordinator at the Directorate of Research and Development, HQUSACE; Ms. Colleen Charles, HQUSACE, served as the CRWRP Technical Monitor's Representative; and Dr. Russell F. Theriot, EL, ERDC, was the CRWRP Program Manager.

Dr. Ellis J. Clairain, Jr., of the Wetlands and Coastal Ecology Branch (WCEB), Ecosystem Evaluation and Engineering Division (EEED), EL, prepared this report. This work took place under the general supervision of Dr. Morris Mauney, Jr., Chief, WCEB; Dr. Conrad Kirby, former Chief, Environmental Resources Division; Dr. John W. Keeley, former Director, EL; Dr. David J. Tazik, Chief, EEED; and Dr. Edwin A. Theriot, Director, EL.

At the time of publication of this report, Dr. James R. Houston was Director of ERDC, and COL John W. Morris III, EN, was Commander and Executive Director.

This report should be cited as follows:

Clairain, E. J., Jr. (2002). "Hydrogeomorphic approach to assessing wetland functions: Guidelines for developing regional guidebooks; Chapter 1, Introduction and Overview of the Hydrogeomorphic Approach," ERDC/EL TR-02-3, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

1 Introduction and Overview of the Hydrogeomorphic Approach

Introduction

At the time of Colonial America, the area now consisting of the current 50 states contained approximately 159 million hectares of wetlands of which approximately 89 million were located in the lower 48 states (Dahl 1990). During the 19th century, wetlands were considered a menace, the cause of malaria, a hindrance for land development, and areas where crop production was constrained (Office of Technology Assessment 1984). Many national and local efforts supported conversion of wetlands to "more productive" land. Through the Swamp Land Acts of 1849, 1850, and 1860, Congress granted to states all swamps and overflow lands for reclamation to reduce destruction caused by flooding and to eliminate mosquito-breeding swamps (Shaw and Fredine 1956). Consequently, over a period of 200 years from 1780 to 1980, the lower 48 states lost an estimated 53 percent of their original wetland area, or approximately 25 hectares of wetlands every hour, during this 200-year period (Dahl 1990). Annual wetland losses decreased from over 267,000 hectares per year during that 200-year period to approximately 117,000 hectares during the period 1974 to 1983 (Dahl and Johnson 1991). Although the rate of loss of wetlands has declined, wetlands continue to be converted to other uses.

During the last two decades, however, there has been a growing awareness of the ecological, social, and economic benefits wetlands provide (The Conservation Foundation 1988). Numerous scientific investigations indicated that wetlands, long recognized as important areas for waterfowl production (Low 1941; Munro 1949; Courcelles and Bedard 1978), also provide habitat for a wide variety of other fish and wildlife species (Ohmart and Anderson 1978; Hendrix and Loftus 2000). Other studies found that wetlands can also reduce flooding by retention of floodwaters (Dewey and Kropper Engineers 1964; Carter et al. 1978; Verry and Boelter 1978). Wetlands can also improve water quality (Kibby 1978; Hammer 1989; Blahnik and Day 2000) by retention of sediments (Boto and Patrick 1979), heavy metals (Lee et al. 1978), or nutrients (Nixon and Lee 1986; Cook 1994; Hiley 1995).

Concurrent with expanded scientific studies on wetlands was an increased public awareness of wetland functions and their values to society. This led to the passage of the Federal Water Pollution Control Act Amendments of 1972, the Clean Water Act of 1977, the Threatened and Endangered Species Act, and state legislation and executive mandates such as Executive Order 11990 - Protection of Wetlands (42 U.S.C.A. 1977, pp 4667-4669). Public attitudes shifted dramatically in the 1970s from the concept of wetlands as wastelands to wetlands as important ecological features in the landscape, as illustrated in President Jimmy Carter's statement that accompanied Executive Order 11990:

> "The Nation's coastal and inland wetlands are vital natural resources of critical importance to the people of this country. Wetlands are areas of great natural productivity, hydrological utility, and environmental diversity, providing natural flood control, improved water quality, recharge of aquifers, flow stabilization of streams and rivers, and habitat for fish and wildlife resources. Wetlands contribute to the production of agricultural products and timber and provide recreational, scientific, and esthetic resources of national interest."

Executive Order 11990 orders that "each Federal agency shall provide leadership and shall take action to minimize the destruction, loss or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands in carrying out the agency's responsibilities." Each agency shall avoid undertaking or providing assistance for new construction located in wetlands unless certain conditions are met. The National Environmental Policy Act also requires consideration of project impacts, including those in wetlands. Therefore, all agencies have a mandate to protect wetlands as much as possible. However, "The Order does not apply to the issuance by Federal agencies of permits, licenses, or allocations to private parties for activities involving wetlands on non-Federal property."

Section 404 of the Clean Water Act (33 U.S.C. 1344) directs the U.S. Army Corps of Engineers, in cooperation with the U.S. Environmental Protection Agency, to administer a regulatory program for permitting discharge of dredged and fill material into "waters of the United States," which by definition includes wetlands and other special aquatic sites. Applications for a permit to discharge dredged or fill material into waters of the United States must undergo a public interest review that includes assessing the impact of the proposed project on wetland functions and other factors related to the public interest. Results of the assessment are one of the factors considered in making the Section 404 permit decision (Smith et al. 1995).

The Corps was placed in a dilemma after passage of the Clean Water Act. It was required to complete permit processing expeditiously to avoid undue burden on the public, but methods to assess wetland functions were limited. There was a wide variety of techniques to assess wetland functions at that time (Larson 1976; Reppert et al. 1979; Michigan Department of Natural Resources 1980; U.S. Fish and Wildlife Service 1980, 1981a, 1981b; Ammann, Franzen, and Johnson 1986; Adamus et al. 1987; World Wildlife Fund 1992), but none was available that could rapidly assess a wide variety of wetland types and diverse wetland functions during any time of year (Lonard et al. 1981; U.S. Environmental Protection Agency 1984), all requirements of the Corps. These methods also could not address many of the Corps basic programmatic or technical requirements (Smith et al. 1995), including

- Standardized and documented approach applicable throughout the public interest review process.
- Applicability across the geographic extent of the Corps' regulatory jurisdiction.
- Applicability to a variety of different wetland types.
- Applicability to a variety of different wetland functions.
- Sensitivity to different types of impacts at levels at which wetland functions are affected.
- Accuracy and precision consistent with the time and resources available.
- Adaptability to a variety of regulatory, management, and planning applications.

Background

In 1991, the Corps of Engineers expanded the Wetlands Research Program at the Environmental Laboratory, Vicksburg, MS, now a part of the U.S. Army Engineer Research and Development Center, and its efforts to develop a wetland assessment technique that could meet the unique requirements of the Corps regulatory mission. The Hydrogeomorphic (HGM) Approach to Assessing Wetland Functions is the product of that effort. Although initially developed for Corps of Engineer regulatory needs, the HGM Approach can be applied to a wide variety of other uses that require examination of potential impacts on wetlands. It can also be used to assess the effectiveness of mitigation plans to compare conditions before and after project implementation, and to project the future with and without a project. See Chapter 9 of the Guidelines from Developing Regional Guidebooks for more discussion on application of the HGM Approach.

The basic concepts of the HGM Approach were developed during the first 3 years of the program and published in 1995 (Smith et al. 1995). A national guidebook was also prepared (Brinson et al. 1995) for riverine wetlands to serve as a template for developing region-specific guidebooks that could then be used to conduct wetland assessments. An approach to classification for grouping wetlands into similar classes was also developed

(Brinson 1993) to facilitate wetland assessments. However, efforts up until 1994 focused, of necessity, on conceptual development of the HGM Approach, with no products developed to implement the concepts. Those concepts, however, showed promise for developing a useful document for application by all Federal agencies. On 24 August 1993 the White House Office on Environmental Policy released the Clinton Administration's comprehensive package of improvements to the Federal wetlands program. It stated that "The agencies will expedite development of a new approach for wetland functional assessment known as the Hydrogeomorphic Classification System (HGM)." It also stated that Executive Order 11990 would be revised "... to direct the Federal agencies to take a watershed/ecosystem approach to wetlands protection and restoration."

In 1994, efforts began to put the concepts into practice. Corps of Engineers district offices were contacted, and volunteers were solicited to work with the Environmental Laboratory to develop regional guidebooks that could be used to assess wetland functions for permit applications. The Corps offices that volunteered and began implementing the concepts of the HGM Approach were the Sacramento, Louisville, Omaha, and Jacksonville Districts, and the New England Division. Working with staff from the Environmental Laboratory and other Federal and state agencies, personnel in these field offices began to grapple with converting concepts to tangible, applicable assessment documents. Small teams were formed, and work began in late 1994.

To determine priorities for developing additional regional guidebooks beyond those in the volunteer districts, a survey was conducted to identify where developmental pressures were resulting in considerable permitting requirements. All districts were requested to indicate which types of wetlands were receiving the greatest developmental pressures and consequently where their permit workload was the greatest. Responses were obtained from 25 of the Corps field offices. Results indicated that approximately 35.7 percent of the permit load nationally was in riverine wetlands (Figure 1) and 24.9 percent in depressions. Subsequently, priorities were solicited from other Federal agencies. Based on these findings and discussions with personnel in individual districts, priorities were established for initiating the development of additional regional guidebooks.

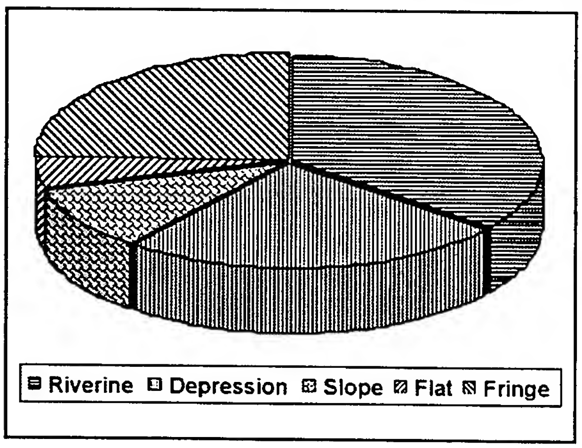

Figure 1. Distribution of permit load by wetland class – October 1995

In addition to the regional efforts started in 1994, and in response to the White House Office on Environmental Policy document, several Federal agencies that work closely with regulating, managing, or impacting wetlands formed a National Interagency Implementation Team. The Team consists of representatives from the Corps of Engineers including the Environmental Laboratory, the U.S Environmental Protection Agency, the U.S. Department of Agriculture Natural Resources Conservation Service, the U.S. Fish and Wildlife Service, the Federal Highway Administration, and the National Oceanic and Atmospheric Administration National Marine Fisheries Service. This Team developed a National Action Plan (*Federal Register* 1997) that provides a strategy the Corps and other Federal agencies will follow to implement the HGM Approach. The Plan identifies the role each of the agencies will perform, provides guidance for quality control for regional guidebook development, training and outreach, and publication sequence; and assigns the Environmental Laboratory as the Technical Support Center for development of the HGM Approach.

During 17-18 October 1995, a meeting was held in the Environmental Laboratory, West Palm Beach, FL, with personnel from each regional effort to discuss lessons learned, progress achieved, and future plans for completion of each effort. Meeting participants developed a sequence of steps or tasks that would be helpful in guiding others who may develop regional guidebooks in the future. Substantial progress has been made in each of these first efforts in applying the initial concepts of the HGM Approach, and numerous others have begun. Those steps served as the foundation for this document and the guidance presented in this and subsequent chapters.

Although there has been a decline in wetland areas over the last two centuries, during the last two decades Federal perception of wetlands has changed. Originally the need to clear and convert land to agricultural production led to wetland losses. However, there has been a growing awareness of wetland functions and their values to society by the scientific and public communities, leading to several legislative mandates to examine projects that may have negative impacts on wetlands and the necessity to develop techniques that can be used to assess wetland ecosystems. The HGM Approach is a consequence of this evolutionary process and thinking.

Objectives of the Guidelines for Developing Regional Guidebooks Document

Initial implementation of the concepts of the HGM Approach was led by the Environmental Laboratory and other Corps of Engineer personnel working closely with other Federal, state, and local agencies. However, development of regional guidebooks is not restricted to the Environmental Laboratory, the Corps of Engineers, or any other single entity; it can be accomplished by Federal, state, or local agency personnel, academia, private consultants, or anyone else. Therefore, it is imperative that there is some level of consistency in the structure and content of each regional guidebook and that the technical foundation of each is rigorous, undergoing considerable technical review and, when necessary, revision. Each guidebook should follow certain steps in development (Table 1) and maintain minimum technical requirements to ensure a quality product.

Table 1
Regional Guidebook Development Sequence

Task	Description
I	Organize regional Assessment Team (A-Team).
A B	Identify A-Team members. Train A-Team in the HGM approach.
II	Identify and prioritize Regional Wetland Subclasses.
A B C D E	Identify Regional Wetland Subclasses. Prioritize Regional Wetland Subclasses. Define reference domains. Initiate literature review. Develop preliminary characterization of the selected regional subclass.
III	Construct conceptual assessment models.
A B C D E F G	Review existing assessment models. Identify and define functions. Identify assessment model variables. Identify field measures and scale of measurement. Define relationship between model variables and functional capacity. Define relationship between variables by developing the aggregation equation for the Functional Capacity Index (FCI). Complete Precalibrated Draft of Regional Guidebook (PDRG)
At this point the document should include a preliminary characterization of the wetland, potential functions with definitions, list of model variables for each function, and a conceptual assessment model for each function with preliminary rationale.	
IV	Peer review of PDRG.
A B C D E	Distribute PDRG to peer reviewers. Conduct interdisciplinary, interagency workshop to review PDRG. Revise PDRG to reflect peer review recommendations. Distribute revised PDRG to peer reviewers for comments. Incorporate final comments from peer reviewers on revisions into PDRG.
V	Calibrate and field test assessment models.
A B C D E F G	Identify reference wetland field sites. Collect data from reference wetland field sites. Analyze reference wetland data. Calibrate model variables using reference wetland data. Verify/validate assessment models. Field test assessment models for repeatability and accuracy. Revise PDRG based on calibration, verification, and validation into a Calibrated Draft Regional Guidebook (CDRG)
At this point the document should include a final characterization of the wetland subclass, functions with definitions, model variables with definitions, calibrated assessment models, a summary matrix of reference data (not raw data sheets) with explanation of how reference data were analyzed and used to calibrate assessment models, and reference wetland location map.	
VI	Peer review CDRG.
A B C D	Distribute CDRG to peer reviewers. Revise CDRG to reflect peer review recommendations. Distribute CDRG to peer reviewers for final comment on revisions. Incorporate final comments from peer reviewers on revisions into the Operational Draft of the Regional Guidebook (ODRG)
VII	Field test the ODRG.
VIII	Transfer technology of ODRG to end users.
A B	Train end users in the use of the ODRC. Provide continuing technical assistance to end users of the ODRG.
IX	Revise ODRG based on field testing and publish revised ODRG.

The objectives of this document are to provide guidance to others who may wish to develop regional guidebooks for different wetland types in other regions of the country. The HGM Approach is not static but rather a dynamic process that has changed considerably since the initial concepts were prepared in 1994. Many of the principles are the same, but the steps to achieve a completed regional guidebook have been revised and refined through trial and error. Substantial effort has been invested, and it is the intent of this document to pass on the lessons learned. It is also intended to assist others so that regional guidebooks can be developed much more efficiently and can maintain a high level of technical accuracy and consistency with other regional efforts. Although the HGM Approach has changed as a consequence of earlier implementation efforts, it is anticipated that it has finally stabilized sufficiently to make this document useful. Since this document represents the evolution of the HGM Approach and the most recent thoughts and ideas of many people, it should also be considered as superceding prior documents in both the status and guidance proposed for regional guidebook development.

The Guidelines for Regional Guidebook Development provides detailed information for anyone wishing to develop regional guidebooks. It will consist of nine chapters. Although not all chapters are complete at this time, it was determined that guidance in those completed chapters would provide valuable information to address several critical steps necessary to complete development of regional guidebooks and, therefore, publication of completed chapters should not be delayed until all other chapters are completed. A short description of each chapter follows:

Chapter 1 - Introduction and Overview of the Hydrogeomorphic Approach. This chapter provides background on the development of the HGM Approach and discusses the major components and phases necessary to implement the HGM Approach. It also presents a brief description of the tasks necessary to complete preparation of a regional guidebook. More detailed discussion of key tasks is provided in subsequent chapters.

Chapter 2 - Identifying and Characterizing Regional Subclasses. This chapter, which is in preparation at this time, will provide further guidance on classifying wetlands into classes using geomorphic setting, water source, and hydrodynamics and further subdividing classes into subclasses using other region-specific characteristics.

Chapter 3 - Developing a Reference Wetland System. This chapter provides definitions of key terms related to reference wetlands. It also describes their purpose and gives guidance on how to select reference wetlands.

Chapter 4 - Developing Assessment Models. This chapter provides guidance for selecting and defining wetland functions, developing the initial conceptual models and variables for each function and refining the conceptual models. Guidance is also provided for developing variable subindexes and for aggregating variables into final models.

Chapter 5 - Collecting and Managing Reference Data. This chapter, which is in preparation, will include guidance for maintaining quality control when collecting reference data, determining minimum sample requirements, selecting different types of field measures, and entering and analyzing data.

Chapter 6 - Calibrating Assessment Models Using Reference Wetland Data. This chapter, which is in preparation, will include different options for calibrating reference data and converting reference data to subindices for each model variable.

Chapter 7 - Verifying, Field Testing, and Validating Assessment Models. This chapter defines each of the three title components and discusses steps necessary to conduct each activity. It also provides guidance for conducting a sensitivity analysis to test the influence of each variable on model outputs.

Chapter 8 - Developing the Assessment Protocol. The Assessment Protocol is one chapter of every regional guidebook. It provides the specific information necessary to collect data including red flag features, office and field equipment needs, plot layout, data collection procedures, and field sheets. Data collected are used to compute model outputs. This chapter in the Guidelines for Regional Guidebook Development, which is in preparation, will include guidance for preparing a list of red flag features, alternatives, and examples for collecting data for each model variable, and developing field sheets.

Chapter 9 - Application of the Hydrogeomorphic Approach. This chapter, which is in preparation, will provide examples of how the results of an HGM analysis can be used to compare multiple wetlands of the same subclass, compute present and future potential project impacts, and determine mitigation requirements.

Overview of the HGM Approach

What is the HGM Approach?

The HGM Approach for assessing wetland functions, developed by scientists at the Environmental Laboratory, is a procedure for measuring the capacity of a wetland to perform functions. It is designed to assess wetland ecosystems, which are normally characterized in terms of their structural components and the processes that link these components (Borman and Likens 1969). Structural components of the ecosystem and the surrounding landscape, such as plants, soils, hydrology, and animals, interact with a variety of physical, chemical, and biological processes. Understanding the interactions of the structural components of the ecosystem with surrounding landscape features is the basis for assessing ecosystem functions, and it is the foundation of the HGM Approach (Smith et al. 1995).

Wetland functions are the normal or characteristic activities that take place in wetland ecosystems (Smith et al. 1995). Wetlands perform a wide variety of functions. However, not all wetlands perform the same functions nor do similar wetlands perform the same function to the same level of performance. The ability to perform a function is influenced by the characteristics of the wetland and the physical, chemical, and biological processes within the wetland. Wetland characteristics and processes influencing one function also often influence the performance of other functions within the same wetland ecosystem.

Wetland functions represent the currency or units of the wetland ecosystem for assessment purposes, but the integrity of the ecosystem is not disconnected from each function. Rather it represents the collective interaction of all wetland functions. Consequently, wetland assessment using the HGM Approach requires both the Assessment Team (A-Team) and end users to recognize that this link between wetland functions and ecosystem integrity is critical. One cannot develop criteria, or models, to maximize a single function without having potentially negative impacts on the overall ecological integrity and sustainability of the whole wetland ecosystem. For example, one should not attempt to create a wetland to maximize water storage capacity without the recognition that other functions, such as plant species diversity, will likely be altered from similar wetland types with less managed conditions. This does not mean that a wetland cannot be developed to maximize a particular function, but that it will typically not be a sustainable ecosystem without future human intervention.

How does the HGM Approach differ from other assessment methods?

The HGM Approach is characterized and differentiated from other wetland assessment procedures in that it first classifies wetlands based on their ecological characteristics (i.e., landscape setting, water source, and hydrodynamics). Second, it uses reference to establish the range of functioning of the wetlands, and third, it uses a relative index of function, calibrated to reference wetlands, to assess wetland functions.

Classification. The HGM Approach uses a hierarchical classification with seven major hydrogeomorphic wetland classes: riverine, depressions, slope, flats (organic soil and mineral soil), and fringe (estuarine and lacustrine). The hydrogeomorphic classification is based on three fundamental factors that influence how wetlands function: the position of the wetland in the landscape (geomorphic setting), the water source (hydrology), and the flow and fluctuation of water once in the wetland (hydrodynamics). Within a specific geographic area, wetland classes can be further divided into regional wetland subclasses (e.g., vernal pools in California, prairie potholes in the northern plains states, and pine flatwoods in the southeastern United

States). Classifying wetlands based on how they function narrows the focus of attention to a specific type or subclass of wetland, the functions that wetlands within the subclass are most likely to perform, and the landscape and ecosystem factors that are most likely to influence how wetlands in the subclass function. This increases the accuracy of the assessment, allows for repeatability, and reduces the time needed to conduct the assessment. See Chapter 2 for more information on hydrogeomorphic classification.

Reference. Reference wetlands are selected from a reference domain (a defined geographic area) and represent sites that exhibit a range of variation within a particular wetland type, including sites that have been degraded/ disturbed as well as sites that have had little disturbance. The use of reference wetlands to scale the capacity of wetlands to perform a function is one of the unique features of the HGM Approach. Reference provides the standard for comparison in the HGM Approach. Unlike other methods that rely on data from published literature or best professional judgement, the HGM Approach requires identification of wetlands from the same regional subclass and from the same reference domain, collection of data from those wetlands, and scaling of wetland variables to those data. Since wetlands exhibit a wide range of variability, reference wetlands should represent the range of conditions within the reference domain. A basic assumption of the HGM Approach is that the highest sustainable functional capacity is achieved in wetland ecosystems and landscapes that have not been subject to long-term anthropogenic disturbance (Smith et al. 1995). It is further assumed that under these conditions the structural components and physical, chemical, and biological processes within the wetland and surrounding landscape reach a dynamic equilibrium necessary to achieve the highest sustainable functional capacity. These wetlands represent a subset of all the reference wetlands and are referred to as Reference Standard Wetlands. Reference standards are derived from these wetlands and are used to calibrate variables. However, it is also necessary to recognize that many wetlands occur in less than standard conditions. Therefore, data must be collected from a wide range of conditions to scale model variables from 0.0 to 1.0, the range used for each variable subindex.

Functional indices. The HGM Approach uses functional indices based on multiple criteria assessment models (Smith and Theberge 1987) to estimate the functional capacity of a wetland (Smith et al. 1995). The assessment models are simple representations of the relationship between the physical, chemical, and biological attributes of the wetland and the surrounding landscape and the functional capacity of the wetland. Variables in the models are scaled to data obtained from the reference wetlands and assigned a subindex ranging from 0.0 to 1.0 with 1.0 assigned to variables with attributes similar to those measured at reference standard sites. As the variable deviates from the reference standard, the subindex is reduced from 1.0. Variables are aggregated into assessment models based on the experience and expertise of A-Team members and recommendations obtained during peer reviews.

Phases of the HGM Approach

Development phase. The HGM Approach includes two phases: a Development Phase and an Application Phase. The Development Phase is conducted by an interagency, interdisciplinary assessment team of wetland experts, the A-Team. The A-Team initially classifies wetlands into different wetland subclasses based on hydrogeomorphic factors (Brinson 1993). For each regional subclass, the A-Team develops a narrative profile describing its physical, chemical, and biological attributes. The profile also includes the functions likely performed by the regional wetland subclass as determined by the experience and technical expertise of the A-Team and from published literature. The A-Team then defines each function, identifies and defines variables related to each function, illustrates the relationship between functions and variables in assessment models, and develops a Precalibrated Draft Regional Guidebook (PDRG) for peer review. After the PDRG has been revised to reflect review comments, the A-Team gathers data from reference wetlands, calibrates the revised models, and field tests the calibrated models. These models define the relationship between attributes and processes of the wetland ecosystem and surrounding landscape and the capacity of a wetland to perform a function. Application of the assessment model results in a Functional Capacity Index (FCI) with a range of 0.0-1.0. The FCI estimates the capacity of a wetland to perform a function relative to other wetlands from the same regional subclass in the reference domain. The standards of comparison used to scale functional indices are reference standards, or the conditions under which the highest sustainable level of function is achieved across a suite of functions performed by reference standard wetlands in a Regional Wetland Subclass. A Calibrated Draft Regional Guidebook (CDRG) is then prepared and, after additional peer review, revised and published as an Operation Draft Regional Guidebook (ODRG). The ODRG is then used by regulators, planners, and others requiring assessment of wetland ecosystems during the application phase.

Implementation of the Development Phase of the HGM Approach is accomplished by completing nine steps or tasks (Table 1). These tasks are not mutually exclusive nor are they carried out solely in sequence. Development of regional guidebooks is an iterative process often requiring examination of information developed during prior tasks and then revising information in subsequent tasks as a result of new data or literature. For example, an A-Team will classify the different wetland subclasses during Task II based on the experience of the team members but may find that classification should be revised after data collection during Task V. There is, however, a logical progression in the Development Phase from formation of an A-Team that develops the regional guidebook to eventual publication as an operational draft.

Application phase. After completion of the development phase, the application phase or assessment procedure can be used to assess wetland functions. The application phase of the HGM Approach, like the development phase, also requires several steps for completion. The assessment procedure includes characterization of the wetland, assessment of site characteristics, and analysis of the assessment results.

Potential uses and limitations

The HGM Approach does not replace the need for delineating a wetland boundary, preclude the sequencing process, nor supercede the Section 404 (b)(1) Guidelines analysis or public interest review. The HGM Approach is a tool that can be used in the alternatives analysis and is expected to be used on those permit actions that warrant a functional assessment for determining wetland impacts. Regulators will be able to use this procedure to determine rapidly and accurately the level of environmental impact of proposed projects, compare project alternatives, identify measures that would minimize environmental impacts, determine mitigation requirements, and establish criteria for measuring mitigation success. As such, the procedure will be helpful in providing greater certainty and reduced permit review times, thus expediting decision making. Some examples where assessment results can be applied include the following (Smith et al. 1995):

- Describe potential impacts of a proposed project.
- Describe the actual impacts of a completed project.
- Identify ways to avoid and minimize impacts of a proposed project.
- Determine the least damaging alternative for a proposed project.
- Determine compensatory mitigation for a proposed project.
- Determine the restoration potential of a wetland.
- Develop design criteria for wetland mitigation or restoration projects.
- Monitor the success of compensatory mitigation efforts.
- Compare wetland management alternatives or results.
- Identify priorities for acquisition or set-aside of wetlands.

As important as it is to know what the HGM Approach was designed to do, it is also important to know what it is not intended to do. The HGM Approach does not assign a value to wetland functions. Value represents the significance of wetland functions to society or individuals and often reflects local priorities or policy issues beyond the scope of the HGM Approach. The FCIs resulting from the HGM Approach cannot be equated to the societal or economic value of that wetland function. The FCIs may be used in combination with other information, however, when assigning values to wetland functions in terms of economic or other value units as required by the public interest review process.

The HGM Approach is also not intended to compare different subclasses of wetlands. Rather results should be used only to compare wetlands from similar subclasses in the same reference domain. Only by obtaining detailed quantitative data (e.g., cubic meters of water storage or grams of carbon m^{-2} yr^{-1}) can different wetlands be combined, but the time and resources required to achieve such a comparison are beyond the scope of the public interest review process and the HGM Approach.

Results from the HGM Approach also cannot be used to assess cumulative impacts as required in the public interest review process (33 CFR 320.4 (a) (3). The HGM Approach is designed to assess wetlands at the ecosystem scale. Although this requires consideration of certain characteristics in the surrounding landscape, the assessment is restricted to the wetland ecosystem. Assessment of cumulative impacts requires consideration of the relationship of one ecosystem to another and the potential influence of one on another at a landscape scale, not solely at an ecosystem scale. Results from the HGM Approach might be used in conjunction with other procedures designed to examine impacts at a landscape scale, such as those by Lee and Gosselink (1988), Leibowitz et al. (1992), and Gosselink et al. (1990).

Tasks Required to Develop Regional Guidebooks

A short description of each of the nine tasks required to develop a regional guidebook using the HGM Approach is provided in the following paragraphs. Subsequent chapters of this document provide much more in-depth information for selected tasks and are noted in the short descriptions provided below.

Task I - Organize Regional Assessment Team (A-Team)

Objective. The objective of Task I is to create a technical team of experts responsible for the overall administration and technical accuracy of the regional guidebook. The A-Team will also be responsible for all aspects of quality control, including data collected.

Approach. Regional guidebooks can be developed by personnel from Federal or state agencies, private industry, or university staff. Regardless of which entity develops a regional guidebook, however, certain steps must be followed (Table 1) to ensure interagency coordination and quality control. It is the role of the A-Team to ensure that those steps are followed, either by developing the regional guidebook itself or by contracting out all or parts of the effort.

Regional guidebooks used to implement the HGM Approach for assessing wetland functions are coordinated and/or developed by an interdisciplinary, interagency team or regional A-Team. The A-Team provides technical and administrative guidance. The A-Team consists of no more than six to eight people representing Federal and state agencies and technical expertise in hydrology, biogeochemistry, plant ecology, and wildlife ecology. The Corps of Engineers should lead the A-Team unless that is designated to someone else on the A-Team. Primary roles of the A-Team are to ensure that the regional guidebook is user-friendly and technically sound and that development of the regional guidebook follows the steps outlined in the National Action Plan (*Federal Register*, June 20, 1997, 62(119), pp. 33607-33620) and this document. The term user-friendly is used to mean that the regional guidebook can be implemented efficiently within the time and resources available to agency personnel when making regulatory decisions (i.e., can the regional guidebook be implemented in 4 hours or less in the field by one or two people with some training and basic ecological background?).

The amount of time required by the A-Team to develop a regional guidebook will vary with the approach used. The A-Team can develop a regional guidebook entirely by itself, contract the entire effort out and coordinate development with the contractor, or use a combination of the two. If the A-Team will be responsible for all aspects of guidebook development, then the effort will require approximately 2 years of effort. However, most of the work is typically accomplished by one or two people on the A-Team, so time demands are substantially less for other team members. Contracting many of the tasks could reduce the time needed to prepare the regional guidebook but will increase the cost.

The A-Team should conduct regularly scheduled meetings and designate a recorder to document meeting results and key decisions. Such documentation will be valuable in preparing the rationale of key components of the regional guidebook. The A-Team should also obtain training in regional guidebook development, preferably during one of the first few A-Team meetings. Training will facilitate development of the regional guidebook and enhance its consistency with those developed by other A-Teams across the country After the training course, the A-Team should schedule several milestones identified in the development of the regional guidebook.

Task II - Identify and Prioritize Regional Wetland Subclasses

Objectives. Objectives of Task II are to classify the different types of wetland subclasses, prioritize the subclasses for which regional guidebooks will be developed, identify the geographic extent of each wetland subclass, and initiate a literature review.

Approach. Once an A-Team is formed and trained, and the role identified that each member will play in the development of the regional guidebook, the A-Team must identify the wetland type for which the regional guidebook will be used. Selection is typically somewhat predetermined by the needs of the regulatory agencies and the developmental pressures on different wetland types that often prompt the formation of the A-Team in the first place. However, often the A-Team initially considers a broad wetland type as the focus, only to find upon careful examination that the regional guidebook should focus more narrowly than initially perceived. For example, the A-Team may feel that a regional guidebook is needed for bottomland hardwoods. However, once the A-Team meets and begins to examine the different hydrogeomorphic wetland types within bottomland hardwoods, the A-Team may find that there are several hydrogeomorphic wetland types and must more clearly define the wetland subclass to focus the regional guidebook. The A-Team can then identify the geographic extent or reference domain of the wetland subclass. This reference domain will be based on the ecological extent of the wetland subclass and not on political or other sociological boundaries. The A-Team should then begin to gather, organize, and review published literature relevant to the wetland subclass and the reference domain. For more information about classification using the hydrogeomorphic approach, see Chapter 2.

Products. The A-Team should have completed classification of the different types of wetlands for which regional guidebooks will be prepared. It should have made a preliminary determination of the geographic extent of the wetland subclass, and developed a narrative description of the wetland subclass including a discussion of the climate, geomorphic setting, water sources, hydrodynamics, soils, vegetation, wildlife, and description of the predominant types of natural and anthropogenic disturbances. Much of this information should be supported with published literature. The A-Team should have started a literature file and begun gathering copies of relevant published literature. That literature file will expand as the A-Team proceeds through subsequent tasks in the regional guidebook development process.

Task III - Construct Conceptual Assessment Models

Objectives. Objectives of Task III are to select and define wetland functions and variables and establish the relationship between wetland functions and variables in assessment models for each function. Sampling protocols will also be established for each variable. A quantitative measure is necessary to allow future testing and validation of the models.

Approach. Once the A-Team has determined the wetland subclass and reference domain, it must begin developing assessment models. Initially it should examine other assessment models and regional guidebooks that may have been developed for similar wetland types. For a list of regional guidebooks and other related information on the HGM Approach, see the Internet at *http://www.wes.army.mil/el/wetlands/hgmhp.html.* The A-Team should also identify and define wetland functions it considers relevant for the wetland subclass. Wetland functions are the normal activities or actions that occur in wetland ecosystems (Smith et al. 1995). The A-Team must be careful to maintain a distinction between wetland functions that are derived from the physical, chemical, and biological attributes of the wetland and wetland values that represent societal priorities or what society considers important. After selection of the wetland functions, each function must be defined and a quantitative measure established as part of the definition.

This quantitative measure is necessary for future validation of the assessment models.

The A-Team must then select variables that indicate the ability of the wetland to perform each function. The variables must also be defined and methods developed to measure each variable. Models must also be developed for each function to illustrate the relationship between the variables and the functions. The same variable may be used to assess different functions, but a different rationale should be prepared. See Chapter 3 for more details about model development.

Products. Completion of Task III will result in the development of a PDRG. With the exception of reference data and assessment models calibrated from that data, the PDRG contains all components provided in a complete regional guidebook (Table 2) including literature and rationale for functions and variables. See Table 3 for terminology and format conventions.

Table 2
Outline for Regional Guidebooks

Chapter 1—Introduction (This chapter is prepared by the Environmental Laboratory and requires only minor tailoring for each specific regional guidebook.)
Background
Objectives
Purpose of the Regional Guidebook
Chapter 2—Overview of the HGM Approach (This chapter is also prepared by the EL.)
Hydrogeomorphic Classification
Reference Wetlands
Assessment Models and Functional Indices
Assessment Protocol
Development Phase
Application Phase
Chapter 3—Characteristics of the Regional Subclass
Define Reference Domain
Define Potential Geographic Extent of the Regional Subclass (ecoregion/Major Land Resource Area)
Characteristics of the Regional Subclass
Climate
Geomorphic Setting
Hydrodynamics
Soils
Vegetation
Wildlife
Disturbances
Natural
Anthropogenic

(Continued)

Table 2 (Continued)

Chapter 4—Wetland Functions and Assessment Models
- Wetland Functions Overview
- Function 1
  - Definition
  - Rationale for Selection of Function (why is this function important in this Regional Wetland Subclass?)
  - Discussion of Attributes, Characteristics, and Processes That Influence the Function and How They Interact to Influence the Function
  - Assessment Model Variables
    - Variable 1
      - Definition
      - Rationale (why include this variable?)
      - Measurement
      - Calibration
      - Transformation of Field Measure to Subindex to Include Range of Reference Data
    - Variable 2 . . . Variable "n"
      - Repeat sequence below Variable 1
    - FCI
      - Aggregation Equation
      - Rationale for Relationship Between Variables (i.e., weighting, combinations, etc.)
- Function 2 . . . Function n
  - Repeat sequence below Function 1

Chapter 5 — Assessment Protocol
- Introduction
- Complete Pre-Assessment Tasks
  - Define Assessment Objectives
  - Site Characterization
    - Gather Materials Necessary to Complete the Assessment
      - Field Equipment
      - Published Materials
    - Measure Variables that Can Be Determined in the Office
    - Complete Preliminary Identification of Wetland Assessment Area (WAA)
  - Screening for Red Flags
  - Bounding the Assessment Area
- Collect Measures of Model Variables
  - Verify Efficacy of Preliminary WAA on Site
  - Verify Variables Measured in the Office
  - Sampling
    - Assessment Data Sheet
    - Identify and Lay Out Representative Sampling Locations
    - Measure Onsite Variables
- Transform Measures of Model Variables into Subindices
  - Data Analysis
- Calculate Functional Capacity Indices
- Apply the Results
  - Provide Calibrated Graphs of all FCI Curves

Chapter 6—References

Appendix A: Glossary/Definitions

Appendix B: Summary Lists and Field Forms
1) Functions with Definitions and Variables
2) Variables with Definitions and Method of Measurement
3) Index of Variables by Functions
4) Index of Functions by Variables
5) Assessment Model Aggregation Equations
6) Other Potentially Useful Summary Lists

Appendix C: Supplementary Information on Model Variables

Supplemental or in-depth information on specific model variables. For example, field measures (such as Manning's Roughness Coefficient picture guides, explanation of how regional curves were developed for calculating return interval, method for converting nonmetric measures of woody debris (i.e., counts of down stems and logs) to metric measures of woody debris (i.e., volume), etc.

(Continued)

Table 2 (Concluded)

Appendix D: Reference Wetland Data Criteria for Selection of Reference Wetlands Methods of Data Collection Raw Data from Reference Wetlands in Matrix Format (not field data sheets) Explanation of How Data Were Analyzed (i.e., testing distributions, correlation regressions, etc.) Explanation of How Data Were Used to Calibrate Model Variables and Assessment Models Location Map for Reference Wetland Sites
Appendix E: Additional Information Any additional information the A-Team feels should be included

Table 3
Terminology and Format Conventions for Use with the HGM Approach

1. Reference to the Hydrogeomorphic Approach: the Hydrogeomorphic (HGM) Approach (first occurrence), the HGM Approach (subsequent occurrences)
2. Reference to wetland function names in text: first letter of each word is uppercase (e.g., Temporary Storage of Surface Water).
3. Reference to variables in text: first letter in each word is uppercase (e.g., Frequency of Flooding).
4. Reference to variables in tables: Capital "V" with capital subscript descriptor (e.g.,V_{FREQ})
5. Reference to the Assessment Team: "Assessment Team," first occurrence; abbreviated option is "A-Team" (subsequent occurrences).
6. Reference to assessment models: "assessment models" (first occurrence); "models" (subsequent occurrences).
7. Reference to subindices: "model variable subindex" (first occurrence); "subindex" (subsequent occurrences).
8. Reference to Functional Capacity Index: first letter in each word is uppercase (e.g., Functional Capacity Unit (FCI) in the first occurrence; later occurrences use FCI)
9. Reference to Functional Capacity Unit: first letter in each word is uppercase (e.g., Functional Capacity Unit (FCU) in the first occurrence; later occurrences use FCU).
10. Reference to the Regional Guidebook: first letter in each word is uppercase (e.g., Regional Guidebook for Low Gradient Riverine Wetlands in western Kentucky).
11. Reference to Regional Wetland Subclass: first letter in each word is uppercase (e.g., Regional Wetland Subclass).
12. Title for Regional Guidebooks: A Regional Guidebook for Applying the Hydrogeomorphic Approach to (fill in the name of particular Regional Wetland Subclass here).
13. Reference to Wetland Assessment Area: first letter in each word is uppercase (e.g., Wetland Assessment Area (WAA) in the first occurrence; later occurrences use WAA).
14. Reference to Partial Wetland Assessment Area: first letter in each word is uppercase (e.g., Partial Wetland Assessment Area (PWAA) in the first occurrence; later occurrences use PWAA).

Task IV - Peer Review of Precalibrated Draft Regional Guidebook

Objectives. Although the PDRG has likely received some technical review outside of the A-Team during the interim stages of development, the primary objective of Task IV is to intensify the level of technical review and expand the number of reviewers to ensure the technical accuracy and utility of the assessment models. Another objective is to obtain recommendations for additional literature and to identify potential field sites for reference wetlands, particularly reference standard wetland sites.

Approach. After the A-Team has developed the PDRG, including a set of draft models with functions and variables defined and rationale, the document must undergo a technical review by personnel familiar with the Regional Wetland Subclass. This technical review should be accomplished in a workshop environment with participation from two broad groups. One group should represent the end users, such as regulatory staff, and include Federal and state agency personnel and personnel from private industry. The other group should be primarily technical, drawn from academia as well as from appropriate end-user personnel. Each workshop participant would attend by invitation only and be required to review the PDRG prior to attending the workshop. Participants should also provide a list of literature relevant to the wetland subclass as well as any suggestions for potential reference wetlands.

Participants should be selected who have technical expertise and experience working in the regional subclass and should provide knowledge in one or more of the disciplines of hydrology, biogeochemistry, plant ecology, and wildlife ecology. The workshop should require approximately 3 days and start with a brief overview of the HGM Approach and discussion of the PDRG, including key assumptions and rationale for functions and variables. The workshop participants should then break into technical workgroups of 6-10 people representing the different disciplines mentioned. Workgroups should contain both academia and end users and at least one member of the A-Team. Those functions relevant for hydrology are reviewed in the hydrology workgroup, those related to biogeochemistry in the biogeochemistry workgroup, etc. Each workgroup should have a facilitator, preferably not from the A-Team, and a recorder. The workgroup will review the wetland subclass and all aspects of the guidebook related to the assigned functions, including definition, rationale for including the function, and supporting literature used. New functions may be added or existing functions deleted or combined with other functions. Any functions determined to be different from those in the PDRG must be defined, a quantitative measure of function provided, and rationale for inclusion developed.

After the review of each function is complete or a new function is developed and defined, rationale prepared, and quantitative measure determined, the workgroup should conduct a similar review of each variable for each function. Each new variable should be defined and a method of measurement determined and described.

At interim stages in the review process, the workgroups should reconvene and each workgroup present progress achieved and recommendations relevant for other workgroups. Questions about new functions proposed in one workgroup but relevant in another should also be discussed and, if appropriate, assigned. A final plenary session should be held to present the final summary and recommendations of each workgroup.

Upon completion of the workshop, the A-Team should examine workshop recommendations, revise the PDRG, and send the revised PDRG to workshop participants for any further recommendations. Key personnel unable to attend the workshop and other additional reviewers may also be provided copies of the revised PDRG for peer review.

Products. Each workgroup should provide a definition of all new or revised functions proposed as well as new rationale for inclusion where appropriate before leaving the workshop. All new variables should also be defined, methods of measurement described, and models presented. Although workshop participants are well intentioned and usually are willing to provide additional information during the workshop, it is the author's experience that little time is available to follow up on these intentions after leaving a workshop. Therefore, it is recommended that all reviews, recommendations, and revisions be developed and prepared before leaving. Since very few, if any, workshop participants are paid to attend, one option, if funds are available, is to have a contractor be responsible for preparing a summary of the workgroup reports and overall workshop results. Such documentation, either from a contractor or from volunteer workshop participants, is important as an interim product in the guidebook development process. It provides a document for the A-Team to refer to as revisions in the PDRG are made and can be very useful in presenting the rationale for certain decisions that must be made in subsequent tasks. For example, a variable may be proposed in the workshop and a sampling protocol provided. However, when the A-Team begins to gather data to calibrate the models, it may be determined that the time required to implement the sampling protocol is too extensive to be practical in the time frame for a rapid assessment method. Another possibility may be that the data are collected for a particular variable but when analyzed, the variable is not sensitive to anthropogenic alterations and must be dropped or replaced with another variable.

Regardless, results of the workshop should be documented and should be maintained by the A-Team to review periodically as further development of the regional guidebook proceeds. The summary should also be provided to the workshop participants within a short period after the workshop so that any additional thoughts can be added and misinterpretations quickly corrected. The final product developed from Task IV is a revised PDRG for subsequent field calibration during Task V.

Task V - Calibrate and Field-Test Assessment Models

Objective. After the PDRG has been revised and a new set of variables developed, the A-Team must collect data from reference wetlands to calibrate each variable. The objectives of Task V are to identify reference wetlands, collect data from those reference wetlands, and calibrate the variables in each model.

Approach. See Chapter 3 for detailed guidance on developing the reference system, Chapter 4 for developing assessment models, Chapter 5 for collecting and managing reference data, Chapter 6 for calibrating the assessment models, and Chapter 7 for field-testing the models.

Product. Upon completion of Task V, the A-Team will have developed a complete draft regional guidebook including variables calibrated with data from reference wetlands. The A-Team will also revise the assessment protocol (Chapter 5 in the regional guidebook) to reflect changes due to implementation of Task V. See Chapter 8 for guidance in developing the assessment protocol. See Table 2 for an outline of the regional guidebook.

Task VI - Peer Review Calibrated Draft of the Regional Guidebook

Objective. The objective of Task VI is to expand the number of people participating in the development of the regional guidebook and to have outside reviewers examine the content and technical assumptions incorporated in the CDRG. This task is designed to serve as a reality check. Often the authors tend to overlook the obvious after having worked with a document for several years. An outside review can often discover errors that could easily be overlooked by those intimately familiar with the regional guidebook.

Approach. This task is best accomplished by several people representing a variety of technical disciplines including hydrology, biogeochemistry, soils, wetland ecology, botany, and wildlife ecology. The level of expertise of the reviewers and the diversity of their technical expertise will often dictate the number of reviewers. However, all should be familiar with the basic concepts, limitations, and objectives of the HGM Approach. All should also be familiar with the ecology of the wetland regional subclass. Reviewers can be drawn from other Federal agencies, state agencies, private industry, or academia. Some may require payment while others may do the work gratis.

Product. The outcome of Task VI is a revised CDRG that incorporates the comments from the peer reviewers. Emphasis here is on ensuring that the technical merits of the regional guidebook are enhanced.

Task VII - Field-Test Operational Draft of the Regional Guidebook

Objective. The objective of the field test is to revisit the field and implement the recommendations from Task VI to ensure that the regional guidebook can be implemented within the original time constraints planned for the HGM Approach.

Approach. The A-Team should visit at least three field sites. One site should represent a reference standard site, one should be a severely degraded site, and one site should represent field conditions somewhere in between. Following the Assessment Protocol included in the regional guidebook and using the field sheets in the guidebook, the A-Team should collect data from the three sites and run the models. One should ask if the sites sort relative to how one might arrange the site conditions based on best professional judgment. If they do not, then the models need further revision.

Product. The results of the field test should be incorporated into the regional guidebook. This step may take very little or no time to accomplish since few surprises should occur at this stage of development.

Task VIII – Transfer Technology of Operational Draft Regional Guidebook to End Users

Objective. Although considerable effort has been achieved to this point in the development phase, it is desirable to again expand the list of participants to include the end users one last time. The objective of this task is to present the ODRG to field personnel for application and to identify and correct any final points of confusion or misinterpretation of the regional guidebook.

Approach. This task is accomplished as a 4-1/2-day field-oriented training course in which participants who may require a wetland assessment technique within the potential reference domain are invited from Federal, state, and local agencies. The course should be led by participants on the A-Team and provide an introduction to the HGM Approach and discussion of all the functions, variables, models, and assessment protocol. The class should be divided into small teams of 3-5 members. A field site should be visited and data collection demonstrated by the instruction team and field forms provided and discussed. Another field site (project site) should be visited where a hypothetical project is planned. Each small team should collect baseline data and project conditions if the hypothetical project were implemented. This comparison of pre- and post-project conditions provides an assessment of potential project impacts. Each small team also samples another site (mitigation site). This second site will represent a potential mitigation area to address project impacts calculated at the project site. Baseline conditions are again computed and a mitigation plan is prepared by each team to determine the level of mitigation necessary to address project impacts. Results are computed four times by each small team (pre- and post-project and pre- and post-mitigation). The last one-half day is used to allow each small team to present the results. Therefore, each small team runs the models under four separate conditions: baseline conditions for project and mitigation sites and projected conditions for project and mitigation field sites. This approach often provides a final acid test of the feasibility of implementing the models and a test of the clarity of guidance in the regional guidebook.

Task IX - Revise Operational Draft of the Regional Guidebook and Publish

Objective. The objective of this final task is to incorporate changes identified by the students in Task VIII and finalize the ODRG for publication.

Product. The revised regional guidebook is prepared for publication and distribution via the Internet at the following URL:

http://www.wes.army.mil/el/wetlands/hgmhp.html

The National Action Plan (*Federal Register* 1997) calls for review of each ODRG within 2 years after publication. Some changes can be implemented more quickly if necessary since the document can be updated and redistributed via the Internet typically without extensive publication costs. The Plan also recommends that each document be further reviewed after 5 years to examine key assumptions since it is anticipated that the state of understanding of wetland ecology could change during that period and that some key assumptions in the regional guidebook may need to be revisited.

References

Adamus, P. R., Clairain, E. J., Jr., Smith, R. D., and Young, R. E. (1987). "Wetland evaluation technique (WET); Vol II, Methodology," operational draft report, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Ammann, A. P., Franzen, R. W., and Johnson, J. L. (1986). "Method for the evaluation of wetlands in New Hampshire," Bulletin No. 9, Connecticut Department of Environmental Protection.

Blahnik, T., and Day, J. (2000). "The effects of varied hydrologic and nutrient loading rate on water quality and hydrologic distributions in a natural forested treatment wetland," *Wetlands* 20(1), 48-61.

Borman, F. H., and Likens, G. E. (1969). "The watershed-ecosystem concept and studies of nutrient cycling." *The ecosystem concept in natural resources management.* G. MI VanDyne, ed., Academic Press, New York, 49-76.

Boto, K. G., and Patrick, W. H. (1979). "The role of wetlands in the removal of suspended sediments." *Wetland functions and values: The state of our understanding; Proceedings of a National Symposium on Wetlands.* P. E. Greeson, J. R. Clark, and E. E. Clark, ed., American Water Resources Association, Minneapolis, MN, 479-489.

Brinson, M. M. (1993). "A hydrogeomorphic classification of wetlands," Technical Report WRP-DE-4, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Brinson, M. M., Hauer, R., Lee, L. C., Nutter, W. L., Rheinhardt, R., Smith, R. D., and Whigham, D. F. (1995). "Guidebook for application of hydrogeomorphic assessments to riverine wetlands," Technical Report WRP-DE-11, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Carter, V., Bedinger, M. S., Nozitki, R. P., and Wilen, W. O. (1978). "Water resources and wetlands." *Wetland functions and values: The state of our understanding; Proceedings of a National Symposium on Wetlands.* P. E. Greeson, J. R. Clark, and J. E. Clark, ed., American Water Resources Association, Minneapolis, MN, 344-376.

Cook, J. G. (1994). "Nutrient transformations in a natural wetland receiving sewage effluent and the implications for waste treatment," *Water Science and Technology* 29, 209-217.

Courcelles, R., and Bedard, J. (1978). "Habitat selection by dabbling ducks in the Baie Noire marsh, southwestern Quebec," *Canadian Journal of Zoology* 57(11), 2230-2238.

Dahl, T. E. (1990). "Wetland losses in the United States 1780's to 1980's," U.S Department of the Interior, Fish and Wildlife Service, Washington, DC.

Dahl, T. E., and Johnson, C. E. (1991). "Status and trends of wetlands of the conterminous United States Mid-1970's to Mid-1980's," U.S. Department of the Interior, Fish and Wildlife Service, Washington, DC.

Dewey and Kropper Engineers. (1964). "Effect of loss of valley storage due to encroachment - Connecticut River," Connecticut Water Resources Committee, Hartford, CT.

Federal Register. (1997). "The National Action Plan to implement the Hydrogeomorphic Approach to assessing wetland functions," June 20, 1997, 62(119), 33607-33620.

Gosselink, J. G., Sasser, C. E., Creasman, L. A., Hamilton, S. C., Swenson, E. M., and Schaffer, G. P. (1990). "Cumulative impact assessment in the Pearl River Basin, Mississippi and Louisiana," LSU-CEI-90-03, Coastal Ecology Institute, Louisiana State University, Baton Rouge, LA.

Hammer, D., ed. (1989). *Constructed wetlands for wastewater treatment: Municipal, industrial, and agricultural.* Lewis Publishers, Chelsea, MI.

Hendrix, A. N., and Loftus, W. F. (2000). "Distribution and relative abundance of the crayfishes *Procambarus alleni* (Faxon) and *P. fallax* (Hagen) in southern Florida," *Wetlands* 20(1), 194-199.

Hiley, P. D. (1995). "The reality of sewage treatment using wetlands," *Water Science and Technology* 32, 329-338.

Kibby, H. V. (1978). "Effects of wetlands on water quality." *Strategies for protection and management of floodplain wetlands and other riparian ecosystems.* R. Johnson and F. McCormick, ed., U.S. Forest Service General Technical Report GTR-WO-12, 289-298.

Larson, J. S., ed. (1976). "Models for assessment of freshwater wetlands," Publication Number 32, Water Resources Research Center, University of Massachusetts, Amherst, MA.

Lee, C. R., Smart, R. M., Sturgis, T. C., Gordon, R. N., and Landin, M. C. (1978). "Prediction of heavy metal uptake by marsh plants based on chemical extraction of heavy metals from dredged material," Technical Report D-78-6, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Lee, L. C., and Gosselink, J. G. (1988). "Cumulative impacts on wetlands: Linking scientific assessments and regulatory alternatives," *Environmental Management* 12, 591-602.

Leibowitz, S. G., Abbruzzese, B., Adamus, P. R., Hughes, E. S., and Irish, J. T. (1992). "A synoptic approach to cumulative impact assessment: A proposed methodology," EPA-600R-92/167, U.S. Environmental Protection Agency, Office of Research and Development, Washington, DC.

Lonard, R.I., Clairain, E. J., Jr., Huffman, R. I., Hardy, L. W., Brown, C. D., Ballard, P. E., and Watts, J. W. (1981). "Analysis of methodologies used for the assessment of wetland values," Final Report, U.S. Water Resources Council, Washington, DC.

Low, J. B. (1941). "Nesting of the ruddy duck in Iowa," *Auk* 58, 506-517.

Michigan Department of Natural Resources. (1980). "Manual for wetland evaluation techniques: Operational draft," Division of Land Resources Programs, Lansing, MI.

Munro, J. A. (1949). "Studies of waterfowl in British Columbia: Green-winged teal," *Canadian Journal of Research* D27, 149-178.

Nixon, S. W., and Lee, V. (1986). "Wetlands and water quality: A regional review of recent research in the United States on the role of freshwater and salt water wetlands as sources, sinks, and transformers of nitrogen, phosphorus, and various heavy metals," Technical Report Y-86-2, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Office of Technology Assessment. (1984). "Wetlands: Their use and regulation," OTA-O-026, U.S. Congress, Office of Technology Assessment, Washington, DC.

Ohmart, R. D., and Anderson, B. W. (1978). "Wildlife use values of wetlands in the arid southwestern United States." *Wetland functions and values: The state of our understanding; Proceedings of a National Symposium on Wetlands.* P. E. Greeson, J. R. Clark, and J. E. Clark, ed., American Water Resources Association, Minneapolis, MN, 278-295.

Reppert, R. T., Sigleo, W., Stackhiv, E., Messman, L., and Meyers, C. (1979). "Wetland values: Concepts and methods for wetlands evaluation," Research Report 79-R-1, Institute of Water Resources, U.S. Army Corps of Engineers, Ft. Belvoir, VA.

Shaw, S. P., and Fredine, C. G. (1956). "Wetlands of the United States," Circular 39, U.S. Fish and Wildlife Service.

Smith, P. G. R., and Theberge, J. B. (1987). "Evaluating natural areas using multiple criteria: Theory and practice," *Environmental Management* 11, 447-460.

Smith, R. D., Ammann, A., Bartoldus, C., and Brinson, M. M. (1995). "An approach for assessing wetland functions using hydrogeomorphic classification, reference wetlands, and functional indices," Technical Report WRP-DE-9, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

The Conservation Foundation. (1988). "Protecting America's wetlands: An action agenda," Final report of the National Wetlands Policy Forum, Washington, DC.

U.S. Environmental Protection Agency. (1984). "Literature review of wetland evaluation methodologies," EPA Region 5, Chicago, IL.

U.S. Fish and Wildlife Service. (1980). "Ecological services manual (101-104 ESM)," U.S. Department of the Interior, Fish and Wildlife Service, Division of Ecological Services, Washington, DC.

U.S. Fish and Wildlife Service. (1981a). "Implementation of the habitat evaluation procedures," FWS/DES-ESM 101, Washington, DC.

U.S. Fish and Wildlife Service. (1981b). "Habitat evaluation procedures," FWS/DES-ESM 102, Washington, DC.

Verry, E. S., and Boelter, D. H. (1978). "Peatland hydrology." *Wetland functions and values: The state of our understanding; Proceedings of a National Symposium on Wetlands.* P. Greeson, J. R. Clark, and J. E. Clark, ed., American Water Resources Association, Minneapolis, MN, 389-402.

World Wildlife Fund. (1992). *Statewide wetland strategies: A guide to protecting and managing the resource.* Island Press, Washington, DC.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)* March 2002	**2. REPORT TYPE** Final report	**3. DATES COVERED** *(From - To)*
4. TITLE AND SUBTITLE Hydrogeomorphic Approach to Assessing Wetland Functions: Guidelines for Developing Regional Guidebooks Chapter 1: Introduction and Overview of the Hydrogeomorphic Approach		**5a. CONTRACT NUMBER** **5b. GRANT NUMBER** **5c. PROGRAM ELEMENT NUMBER**
6. AUTHOR(S) Ellis J. Clairain, Jr.		**5d. PROJECT NUMBER** **5e. TASK NUMBER** **5f. WORK UNIT NUMBER** 32985
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) U.S. Army Engineer Research and Development Center Environmental Laboratory 3909 Halls Ferry Road Vicksburg, MS 39180-6199		**8. PERFORMING ORGANIZATION REPORT NUMBER** ERDC/EL TR-02-3
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) U.S. Army Corps of Engineers Washington, DC 20314-1000		**10. SPONSOR/MONITOR'S ACRONYM(S)** **11. SPONSOR/MONITOR'S REPORT NUMBER(S)**

12. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT

The Hydrogeomorphic (HGM) Approach for assessing wetlands was developed by the U.S. Army Corps of Engineers as a procedure for measuring the capacity of a wetland to perform functions. The Approach requires classification of wetlands based on geomorphic setting, water source, and hydrodynamics. For each wetland type, or subclass, it also requires developing models for each classified wetland, collecting data from reference wetlands, and calibrating the models using that data. The calibrated models are then field tested, revised, and published as a regional guidebook. The HGM Approach provides a tool to assess wetland functions, compute potential project impacts, calculate mitigation requirements, and project future with and without potential project conditions. Basic concepts for the HGM Approach were published in 1995, but implementation of the concepts to prepare regional guidebooks was initiated the previous year. It quickly became apparent that conversion from concepts to reality would require more detailed instructions and guidance. The objective of the Guidelines for Regional Guidebook Development is to provide that detailed guidance. These Guidelines contain detailed information on the background and overview of the HGM Approach; specific information on wetland classification; guidance on selecting reference wetlands, developing assessment models, collecting data from reference wetlands, and using that data to calibrate, verify, field test, and

(Continued)

15. SUBJECT TERMS

Assessment models	HGM	Hydrogeomorphic classification	Reference wetlands	Wetland assessment
Functional assessment	Hydrogeomorphic approach	Reference standard wetlands	Regional guidebooks	Wetland functions

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON**
a. REPORT UNCLASSIFIED	**b. ABSTRACT** UNCLASSIFIED	**c. THIS PAGE** UNCLASSIFIED		32	**19b. TELEPHONE NUMBER** *(include area code)*

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. 239.18

Abstract (Concluded).

validate the assessment models; and examples of potential application of model results to determine project impacts, mitigation requirements, and projections of futures with and without project conditions.

Chapter 1 of the Guidelines for Regional Guidebook Development contains an overview and introduction to the HGM Approach and a general description of each of the nine tasks necessary to prepare regional guidebooks specific for particular wetland types. Although the tasks are presented in a linear fashion, development of regional guidebooks is typically accomplished in an iterative process with information developed in one task used to refine a previous task. Subsequent chapters of the Guidebook for Regional Guidebook Development provide more detail about each of the tasks presented in Chapter 1.